plants for generating electricity throughout central and northern California was general during 1920. Because of the high price of fuel oil, and the increased cost of transportation and higher labor charges, the public utility commission granted the power companies permission to raise rates on electricity 15 per cent. This served as an excuse for higher rents, and all residents thus felt another increase in the cost of living, indirectly due to the deficient precipitation of last winter. The street car companies, the largest single users of electricity, adopted the skip-stop system to reduce consumption of energy, and also took off many cars to reduce the demand for power. Through moral suasion and a simple presentation of the facts, the utility commission's power administrator succeeded in eliminating all electric advertising signs on five nights of the week, and the unnecessary lighting of store windows and streets was reduced. In the mountain regions many mines using electric power were compelled to shut down. Gold dredgers using electricity ceased to operate.

In the Santa Clara Valley the well situation became serious in midsummer, owing to the depletion of underground waters. Emergency measures were adopted to preserve the levels of these underground waters so that the overlying orchards could be saved.

At the United States Immigration Station on Angel Island, in San Francisco Bay, the only well on the island went dry in midsummer, and fresh water had to be transported by barge from Marin County.

Due to the deficient precipitation of the past four rainy seasons, the forests in the elevated regions of California became very dry and suffered severe injury from fire during the summer. August, 1920, was perhaps the most disastrous month for forest fires which the State has thus far experienced. The situation became so serious that billboard posters were displayed by the United States Forest Service, informing citizens of the situation and cautioning those going to the forests for recreation to be particularly careful in the use of fire. Experienced fire-fighters were transported by aeroplane to the larger conflagrations. Lightning was a prolific source of fires in the parched forests throughout the long dry summer. The "back fire" from an automobile truck passing near Paradise, Butte County, set fire to a dry pasture, and 15,000 acres were burned over before the fire was controlled.

Relief came as a result of copious showers and cool weather in October. Fruit trees were revived, the forest-fire hazard was reduced, and the hydroelectric situation was relieved to such an extent that all power restrictions were immediately removed. Thus ended a season in which more attention was paid to rainfall statistics than ever before in the history of California. It is no exaggeration to say that for the past year the official rainfall data have occupied a place in public interest on a par with vital statistics, bank clearings, stock quotations, and market reports.

In commenting on the situation, the San Francisco Chronicle in an editorial on August 13 stated:

> Rain or shine, for the next decade the most important matter before our people will be the storage, so far as humanly possible, of every drop of water which falls on the State, and its utilization for irrigation and the development of power.

THE RELATION OF PROLONGED TROPICAL DROUGHTS TO SUN SPOTS.

By Prof. W. H. PICKERING.

[Mandeville, Jamaica, July 2, 1920.]

SYNOPSIS.

A study of the collected rainfall data covering the last 50 years in the island of Jamaica has shown that there have been 12 droughts, 9 of which have followed closely after a sun-spot maximum or minimum. It appears that droughts occurring after the maxima show a greater deficiency of rainfall, and last longer, than those occurring after the minima. On the basis of sun-spot data a drought, predicted in March, 1919, to begin during 1919 or 1920, actually began in June, 1919, and was continuing at the time of writing the paper. It is suggested that the cause of the variations of rainfall may lie in the effect of changes in ocean temperatures on condensation and evaporation in the Tropics, and the increased solar magnetic activity after sun-spot maxima, although the reason for such a solar relation is not apparent. The effects of volcanic dust on radiation may also be a factor.—*C. L. M.*

The island of Jamaica is situated south of Cuba, in latitude 18° N. Its area is 4,200 square miles, or a trifle less than that of the State of Connecticut. The whole island is mountainous, culminating in the east in Blue Mountain Peak, 7,360 feet in height, but in the greater part of the island the elevations do not exceed 2,000 to 3,000 feet. At the suggestion and under the superintendence of the late Maxwell Hall, the Government, in 1870, began publishing the rainfall data for the island, and the fiftieth year has just been completed.

The rain is collected in gauges 5 inches in diameter with their tops elevated 1 foot above the ground. The observers are Government officials, planters, and cattlemen. In 1870 there were 24 stations, one of them dating back to 1862. Less than a dozen of these original stations are still maintained, others taking their place. On January 1, 1920, there were 196 stations, or one for every 22 square miles of territory, scattered as uniformly as practicable over the island. At no station here considered have the observations been continued for less than 10 years.

The rainfall is very unequal in different portions of the island. Thus at Moore Town near the entrance of a funnel-shaped valley at the extreme eastern end of the island, altitude 600 feet, where the trade winds impinge on the high mountains, the annual rainfall is 248 inches. On Blue Mountain Peak itself it is 175. On the other hand, at Bull Bay, 8 miles east of Kingston, and 20 miles from Moore Town, but on the other side of the mountains, it is only 33. The island has therefore been divided into four nearly equal sections according to their topographic features, and in Table 1 the rainfall is given for each of these sections and also for the island as a whole by decades. The mean rainfall for the island for the 50 years is 72.86 inches. It will be at once noticed that the means for the first two decades of this rainfall are very similar, and also the means for the last three, but that the two results differ from one another by about 10 inches. By examining the deviations from the mean, we see that the increased precipitation of recent decades is recorded mainly in the two rainiest sections of the island, the northeastern and west central, but that the other sections also show an appreciable increase. There does not seem to be any evidence that the change is due to the abandonment of certain stations and the establishment of others, but rather to an actual increase in the rainfall over the whole island.

In Table 2, in the second column, is given the mean annual rainfall for successive years, and in the third these results are smoothed by the well-known device of taking the mean of the first five results from the second column and entering it on the third line. The mean of the second, third, fourth, fifth, and sixth results is entered on the fourth line, and so on. These results are plotted in figure 1 and show clearly the gradual increase of rainfall. Owing to the drought of the present year, the next point to be entered will be appreciably lower than the last. If we have now reached a maximum, and the results are periodic, the semiperiod is 44 or 35 years. According to the Brückner whole period of 35 years, the interval from 1871 to 1885, inclusive, should be wet and the following interval dry. This does not seem to be borne out by the facts.

In Table 3 is given the rainfall by months. Two means are taken, one for the two earlier dry decades and the other for the three later wet ones. It will be noted that the rainfall in January, May, August, and December has not materially altered, but that in April and in each of the three autumn months the increase exceeds an inch, the late autumn rain thus becoming much more marked than formerly. In Table 4 is given the rainfall by months and the deviation from the means as found in Table 3. The last columns give the duration and maximum deficiency of every prolonged drought that lasted at least 10 months and exceeded 12 inches. The two most severe droughts not entered in the table occurred in 1882 and in 1918. The first of these showed a deficiency of 11 inches and lasted 9 months. The deficiency of the

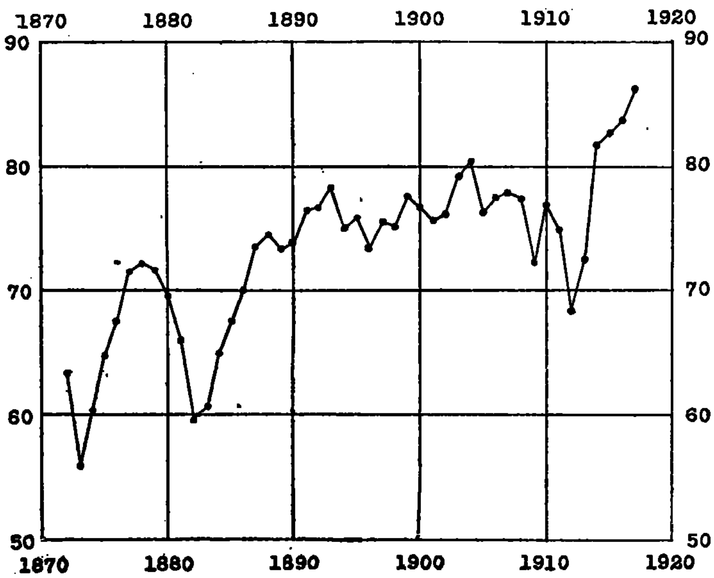

FIG. 1.—Smoothed graph of the rainfall in Jamaica, 1870–1920.

other amounted to 13 inches, but its duration was only 7 months. Numerous less marked droughts also occur, increasing in numbers as the required conditions are made less and less severe.

In the first two columns of Table 5 the dates of the droughts are expressed in years and tenths and the deficiency in inches, the decimal being omitted. The third column gives the duration in months, and the fourth the dates of the sun-spot maxima and minima since 1870, the latter being printed in italics. The first six of these dates are taken from Miss Clerke's *History of Astronomy*, fourth edition, 462. For the last three I am indebted to Prof. Adams, the eighth being Wolfer's revised value, and the last the result obtained at Mount Wilson. The fifth column gives the differences between the numbers in the first and fourth. It will be noted that every sun-spot maximum and minimum has been followed by a drought, and that three other droughts have also occurred, 12 in all. The last numbers in the second and hird columns are followed by a +, since the present drought is not yet over.

In Table 6 the first four columns indicate that the average of these differences for the four maxima, taken from the fifth column of Table 5, is 2.3 ± 0.5 years, and the average for the four minima is 1.4 ± 0.3 years. These differences may, for convenience of predicting future droughts, be expressed as two years four months, and one year five months. The 12 droughts have occurred on the average at intervals of 4.17 years. If their relation to the sun spots was due merely to chance, the average deviation should be one-fourth of this, or 1.04 years. Not one of the deviations in Table 6 reaches this figure. From this we conclude, considering the inevitable errors occurring in fixing the exact dates of the sun-spot maxima and minima, that a real relation subsists between these dates and those of the Jamaica droughts.

The fifth and sixth columns show that the average deficiency at a sun-spot maximum is 32 inches, and at a minimum 20. The next two columns show that the average durations are 20 and 13 months, respectively, and the last two, obtained by dividing the deficiency by the duration, that the average intensities are 1.7 and 1.5 inches per month. It therefore appears that the droughts occurring after the maxima not only show a greater deficiency, but also last longer and are more intense than those occurring after the minima.

The three droughts not associated with the sun spots had an average deficiency of 23 inches, a duration of 14 months, and an intensity of 1.6. They were therefore very slightly more severe than those occurring after the minima. From this we conclude that while the condition of the solar surface is an index to the majority of the prolonged Jamaica droughts, there is some other less important cause also at work, occasionally producing a similar result. [See discussion by W. J. H., below.] If we were willing to include a very minor drought, whose maximum occurred in April, 1888, whose deficiency was 9.48 inches, and its duration 5 months, we might consider these droughts, too, to be periodical. The intervals between them last, respectively, for 12.5, 11.3, and 13.1 years; mean 12.3.

It may be noted in passing that on the strength of a preliminary investigation published in the Annals of Harvard College Observatory, **82**:16, and on the sun-spot data communicated to the writer by Prof. Adams, a drought was predicted for Jamaica to occur during the year 1919 or 1920. This prediction was published in the local island paper in March, 1919. The drought actually began, as shown in Table 4, in June, 1919, and has not ended as yet. Deficiency so far 22.84 inches, Table 4. By the more accurate data here given the beginning would have been set for the summer of 1919, and the end for the autumn of 1920, with a maximum deficiency of about 30 inches. If the mean could be relied on, the drought would last through November. It may be added that the drought has extended throughout the whole of the West Indies, from Cuba to British Guiana, and in places has caused considerable suffering from the failure of crops, and a deficiency in the sugar output.

As to its cause, it may be stated that the deficiency of rainfall appears to be due mainly to a deficiency in the spring and autumn months, which bring us most of our rain. During the last three droughts the lack of rain has been associated with a lack of heavy afternoon cloud, our rainfall occurring chiefly in the afternoon. It therefore appears probable that the droughts are due mainly to a lack of density in the tropical belt of cloud which follows the sun north and south in its yearly course through the heavens. Why the density of this cloudy belt should vary with the sun spots is not very clear, but it may be noted that the maximum intensity of the solar magnetic storms, and the greatest rate of change in the solar activity, is said to occur about two years after the sun-spot maxima. (Journal British Astronomical Association, 1920, **30**: 186.) It would seem that since there is no appreciable change in the insolation, that a change in the rate of solar activity after the maxima and again after the minima would be more likely to affect terrestrial evaporation and condensation than the mere spottedness of the sun's surface.

In closing it should be stated that the first suggestion of the relation between the Jamaica rainfall and the semiperiod of the sun spots is to be found in Maxwell Hall's Rainfall of Jamaica, second edition, 1911. Sir Norman and Dr. W. J. S. Lockyer had previously found a similar relation in the rainfall of India. It should also be mentioned that the writer has received much assistance in the collection of the more recent data, as well as in the correction of certain typographical errors in that which had been already published, from the island's Associate Meteorologist, Miss C. Maxwell Hall.

TABLE 1.—*Rainfall by sections, in inches.*

Decade.	N. E.	Dev.	N.	Dev.	W. C.	Dev.	S.	Dev.	Island.	Dev.
1870–1879...	91.04	− 4.88	57.34	+0.68	70.73	−12.84	50.53	−4.76	67.41	−5.45
1880–1889....	84.96	−10.96	50.96	−5.70	75.74	− 7.83	54.51	−0.78	66.54	−6.32
1890–1899....	98.60	+ 2.68	57.36	+0.70	92.17	+ 8.60	56.45	+1.16	76.15	+3.29
1900–1909....	99.48	+ 3.56	57.37	+0.71	89.21	+ 5.64	61.90	+6.61	76.98	+4.12
1910–1919....	105.50	+ 9.58	60.28	+3.62	90.01	+ 6.44	53.07	−2.22	77.21	+4.35
Average..	95.92	± 6.33	56.66	±2.28	83.57	± 8.27	55.29	±3.10	72.86	±4.70

TABLE 2.—*Annual rainfall.*

Year.	Rain.	Smoothed.	Year.	Rain.	Smoothed.	Year.	Rain.	Smoothed.
1870.......	89.43	....	1887.......	70.66	73.48	1904.......	88.15	80.36
1871.......	50.09	....	1888.......	72.11	74.39	1905.......	85.20	76.21
1872.......	45.18	63.34	1889.......	74.15	73.20	1096.......	86.71	77.46
1873.......	63.06	55.94	1890.......	64.42	73.88	1907.......	52.61	77.86
1874.......	68.94	60.19	1891.......	84.70	76.55	1908.......	74.62	77.37
1875.......	52.42	64.85	1892.......	73.00	76.80	1909.......	90 17	72.21
1876.......	71.35	67.52	1893.......	86.49	78.24	1910.......	82.76	76.94
1877.......	68.49	71.50	1894.......	75.39	75.02	1911.......	60.90	74.88
1878.......	76.42	72.10	1895.......	71.62	75.94	1912.......	76.26	68.32
1879.......	88.84	71.56	1896.......	68.61	73.40	1913.......	64.34	72.76
1880.......	55.44	69.43	1897.......	77.59	75.50	1914.......	57.36	81.84
1881.......	68.60	66.00	1898.......	73.82	75.10	1915.......	104.95	82.78
1882.......	57.87	59.61	1899.......	85.82	77.57	1916.......	106.32	83.70
1883.......	59.26	60.50	1900.......	69.65	76.72	1917.......	80.93	86.11
1884.......	56.90	64.90	1901.......	80.96	75.64	1918.......	68.92	....
1885.......	59.86	67.46	1902.......	73.37	76.10	1919.......	69.45	....
1886.......	90.61	70.03	1903.......	68.38	79.21			

TABLE 3.—*Mean rainfall by months, in inches.*

Decade.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1870–1879 .	4.46	2.38	3.34	3.25	9.05	4.74	4.31	6.66	6.85	10.07	6.71	5.59
1880–1889 .	3.78	2.51	2.49	4.18	9.07	7.77	4.32	6.83	6.87	8.04	5.08	5.60
Average.	4.12	2.44	2.92	3.72	9.06	6.26	4.32	6.74	6.86	9.06	5.89	5.59
1890–1899 .	3.13	2.97	2.75	5.17	10.56	5.81	5.64	6.35	7.64	13.01	7.71	5.41
1900–1909 .	4.27	3.30	3.96	4.59	7.93	9.73	4.76	6.84	8.28	10.15	8.09	5.08
1910–1919 .	4.04	2.75	3.54	6.03	9.12	5.61	4.70	7.42	8.26	9.51	10.60	5.61
Average.	3.81	3.01	3.42	5.26	9.20	7.05	5.03	6.87	8.06	10.89	8.80	5.37

TABLE 4.—*Rainfall by months.*

Year.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.		Droughts.	
	Rain.	Variation.	Rain.	Variation.	Rain.	Variation.	Rain.	Variation.	Rain.	Variation.	Rain.	Variation.	Rain.	Variation.	Rain.	Variation.	Rain.	Variation.	Rain.	Variation.	Rain.	Variation.	Rain.	Variation.	Duration.	Deficiency (inches).
1870..............	3.99	−0.13	4.35	+1.91	3.10	+0.18	2.79	−0.93	17.38	+ 8.32	3.58	− 2.68	4.38	+0.01	5.72	−1.02	8.05	+1.19	16.74	+ 7.68	12.50	+ 6.61	6.90	+ 1.31	....	
1871..............	2.40	−1.72	1.60	−0.84	2.29	−0.63	3.46	−0.26	6.43	− 2.63	1.98	− 4.28	3.79	−0.53	3.46	−3.28	5.70	−1.16	8.88	− 0.18	5.88	− 0.01	4.22	− 1.37	Jan.-	38.69
1872..............	3.00	−1.12	2.84	+0.40	3.06	+0.14	2.06	−1.66	5.18	− 3.88	2.41	− 3.85	2.89	−1.43	5.24	−1.50	4.55	−2.31	6.09	− 2.97	3.13	− 2.76	4.73	− 0.86	Dec.	
1873..............	8.15	+4.03	1.94	−0.50	5.47	+2.55	1.15	−2.57	5.06	− 4.00	2.58	− 3.68	2.56	−1.76	7.51	+0.77	10.73	+3.87	8.57	− 0.49	3.53	− 2.36	5.81	+ 0.22	....	
1874..............	3.44	−0.68	2.20	−0.24	0.61	−2.31	4.40	+0.68	10.65	+ 1.59	3.96	− 2.30	2.57	−1.81	9.65	+2.91	6.82	−0.04	11.69	+ 2.63	10.52	+ 4.63	2.49	− 3.10	Dec.-	18.81
1875..............	2.57	−1.55	0.67	−1.77	2.59	−0.33	3.05	−0.67	8.54	− 0.52	3.74	− 2.52	3.87	−0.45	5.13	−1.61	7.60	+0.74	5.58	− 3.48	2.34	− 3.55	6.71	+ 1.15	Nov.	
1876..............	6.00	+1.88	0.96	−1.48	1.63	−1.29	4.68	+0.96	8.04	− 1.02	5.40	− 0.86	8.15	+3.83	5.06	−1.68	5.19	−1.67	11.36	+ 2.30	8.96	+ 3.07	5.72	+ 0.13	....	
1877..............	5.94	+1.82	1.18	−1.26	5.38	+2.46	2.91	−0.81	15.03	+ 5.97	6.50	+ 0.24	4.68	+0.36	1.76	−4.98	5.01	−1.85	4.50	− 4.56	7.63	+ 1.74	7.88	+ 2.29	....	
1878..............	6.35	+2.23	2.80	+0.36	2.78	−0.14	0.70	−3.02	4.86	− 4.20	6.63	+ 0.37	5.85	+1.53	10.80	+4.06	7.43	+0.57	11.29	+ 2.33	7.32	+ 1.43	9.61	+ 4.02	....	
1879..............	2.81	−1.31	5.30	+2.86	6.49	+3.57	7.28	+3.56	9.14	+ 0.08	10.64	+ 4.38	4.47	+0.15	12.32	+5.58	7.38	+0.52	15.96	+ 6.90	5.29	− 0.60	1.76	− 3.83	Nov.-	17.32
1880..............	4.36	+0.24	0.96	−1.48	1.10	−0.82	2.77	−0.95	11.60	+ 2.54	3.09	− 3.17	3.86	−0.46	9.58	+2.84	3.97	−2.89	4.00	− 5.06	2.21	− 3.68	7.94	+ 2.35	Nov.	
1881..............	1.22	−2.90	4.01	+1.57	1.30	−0.42	4.63	+0.91	10.28	+ 1.22	5.56	− 0.70	4.77	+0.45	6.21	−0.53	7.68	+0.82	12.08	+ 3.02	7.52	+ 1.63	3.34	− 2.25	....	
1882..............	2.92	−1.20	1.93	−0.51	3.54	+0.62	3.32	−0.40	8.22	− 0.84	2.33	− 3.93	3.76	−0.56	4.80	−1.94	8.78	+1.92	8.96	− 0.10	5.36	− 0.53	3.95	− 1.64	....	
1883..............	5.49	+1.37	3.50	+1.06	4.08	+1.16	3.34	−0.38	5.29	− 3.77	4.98	− 1.28	3.15	−1.17	5.42	−1.32	7.82	+0.96	8.15	− 0.91	5.12	− 0.77	2.92	− 2.67	....	
1884..............	4.72	+0.60	3.44	+1.00	2.57	−0.41	1.85	−1.87	6.72	− 2.34	6.89	+ 0.63	2.52	−1.80	5.06	−1.68	6.23	−0.63	9.52	+ 0.46	5.00	− 0.89	2.44	− 3.15	Apr.-	38.59
1885..............	1.73	−2.39	1.49	−0.95	1.47	−1.45	4.73	+1.01	4.90	− 4.16	3.32	− 2.94	3.01	−1.29	6.19	−0.55	6.22	−0.64	6.37	− 2.69	4.74	− 1.15	15.69	+10.10	Nov.	
1886..............	5.32	+1.11	4.56	+2.21	2.68	−0.24	6.39	+2.67	5.30	− 3.76	23.36	+17.10	6.22	+1.90	13.54	+6.80	5.90	−0.96	7.98	− 1.08	3.70	− 2.19	5.66	+ 0.07	....	
1887..............	6.02	+1.90	2.32	−0.12	2.38	−0.54	4.47	+0.75	9.32	+ 0.26	8.89	+ 2.63	7.19	+2.87	6.91	+0.17	5.77	−1.09	8.47	− 0.59	8.17	+ 2.28	0.75	− 4.84	....	
1888..............	1.36	−2.76	1.89	−0.55	1.70	−1.22	3.61	−0.11	21.24	+12.18	6.77	+ 0.51	2.65	−1.67	5.47	−1.27	8.10	+1.24	4.38	− 4.68	4.59	− 1.30	10.35	+ 4.76	....	
1889..............	4.78	+0.66	0.90	−1.54	4.19	+1.27	6.71	+2.99	7.82	− 1.24	12.52	+ 6.26	6.08	+1.76	5.12	−1.62	8.20	+1.34	10.49	+ 1.43	4.37	− 1.52	2.97	− 2.62	....	
1890..............	5.21	+1.40	2.92	−0.09	5.84	+2.42	3.37	−1.89	5.57	− 3.63	4.13	− 2.92	4.99	−0.04	6.92	+0.05	6.52	−1.54	7.04	− 3.75	6.52	− 2.28	5.39	+ 0.02	Apr.-	19.69
1891..............	3.45	−0.36	2.24	−0.77	0.84	−2.58	8.49	+3.23	12.28	+ 3.08	9.91	+ 2.86	5.57	+0.54	7.45	+0.58	6.35	−1.71	15.32	+ 4.43	7.65	− 1.15	5.15	− 0.22	Mar.	
1892..............	4.00	+0.19	1.38	−1.63	2.27	−0.55	2.82	−2.44	8.53	− 0.67	7.31	+ 0.26	4.44	−0.59	7.65	+0.78	8.86	+0.80	12.17	+ 1.28	9.96	+ 1.16	3.61	− 1.75	....	
1893..............	3.44	−0.37	3.24	+0.23	1.92	−1.50	5.42	+0.16	10.90	+ 1.70	7.20	+ 0.15	9.15	+4.12	6.72	−0.15	7.92	−0.14	10.30	− 0.59	10.10	+ 1.30	10.81	+ 5.44	....	
1894..............	2.05	−1.76	2.52	−0.49	3.33	−0.09	5.84	+0.58	16.64	+ 7.44	3.90	− 3.15	5.92	+0.89	4.20	−2.77	6.98	−1.08	12.40	+ 1.51	5.05	− 3.75	6.56	+ 1.19	....	
1895..............	1.31	−2.50	5.00	+1.99	2.18	−1.24	6.11	+0.85	9.90	+ 0.70	3.66	− 3.39	4.99	−0.04	8.11	+1.24	6.87	−1.19	11.98	+ 1.09	7.72	− 1.08	3.79	− 1.58	....	
1896..............	5.25	+1.44	4.86	+1.85	4.28	+0.86	3.67	−1.59	9.96	+ 0.76	4.84	− 2.21	5.03	0.00	4.74	−2.13	8.24	+0.18	7.57	− 3.38	4.57	− 4.23	5.66	+ 0.29	June-	18.25
1897..............	0.88	−2.93	0.77	−2.24	1.82	−1.60	7.06	+1.80	10.91	+ 1.71	4.92	− 2.13	5.92	+0.89	6.55	−0.32	10.13	+2.07	19.26	+ 8.37	5.73	− 3.07	3.64	− 1.73	Mar.	
1898..............	1.75	−2.06	3.93	+0.92	1.26	−2.16	4.09	−1.17	16.76	+ 7.56	7.60	+ 0.55	6.50	+1.47	6.92	+0.05	7.10	−1.96	10.38	− 051	4.78	− 4.02	2.75	− 2.62	Sept.-	21.08
1899..............	3.96	+0.15	2.84	−0.17	3.76	+0.34	4.80	−0.46	4.20	− 5.00	4.66	− 2.39	3.86	−1.17	4.22	−2.65	7.44	−0.62	23.72	+12.84	14.99	+ 6.19	7.37	+ 2.00	Sept.	
1900..............	5.20	+1.39	4.15	+1.14	2.42	−1.00	5.67	+0.41	7.77	− 1.43	6.16	− 0.89	7.18	+2.15	5.38	−1.49	8.12	+0.06	6.50	− 4.39	5.22	− 3.58	5.88	+ 0.51	....	
1901..............	3.91	+0.10	1.17	−1.84	3.32	−0.10	2.57	−2.69	6.13	− 3.07	14.03	+ 6.98	7.59	+2.46	6.49	−0.38	10.60	+2.54	9.76	− 1.13	10.02	+ 1.22	5.37	0.00	....	
1902..............	5.68	+1.87	3.06	+0.05	4.24	+0.82	5.40	+0.14	8.97	− 0.23	10.28	+ 3.13	3.44	−1.59	5.39	−1.48	5.89	−2.17	7.19	− 3.70	5.60	− 3.20	8.23	+ 2.86	July-	13.25
1903..............	1.94	−1.87	1.40	−1.61	3.19	−0.23	4.90	−0.36	10.63	+ 1.43	6.00	− 1.05	4.30	−0.73	12.79	+5.92	5.34	−2.72	7.28	− 3.61	5.78	− 3.02	4.83	− 0.54	Apr.	
1904..............	3.42	−0.39	4.66	+1.65	6.84	+3.42	5.91	+0.65	7.57	− 1.69	15.20	+ 8.15	4.26	−0.77	5.47	−1.40	6.49	−1.57	16.58	+ 6.31	7.87	− 0.93	3.94	− 1.43	....	
1905..............	7.83	+4.02	2.99	−0.02	7.48	+4.06	5.14	−0.12	8.20	− 1.00	10.10	+ 3.05	2.73	−2.30	6.17	−0.70	8.27	+0.21	12.36	+ 1.47	6.77	− 2.03	7.17	+ 1.80	....	
1906..............	3.37	−0.44	5.15	+2.14	5.50	+2.08	8.02	+2.76	13.23	+ 4.03	11.47	+ 4.42	4.19	−0.84	6.98	+0.11	10.70	+2.64	8.44	− 2.45	7.60	− 1.20	2.06	− 3.31	Oct.-	31.12
1907..............	2.58	−1.23	3.75	+0.74	0.36	−3.06	1.24	−4.02	5.12	− 4.08	5.96	− 1.09	4.26	−0.77	4.63	−2.24	5.39	−2.67	10.51	− 0.38	4.26	− 4.54	4.55	− 0.82	Dec.	
1908..............	4.38	+0.57	5.05	+2.04	3.42	0.00	3.45	−1.81	4.92	− 4.28	11.65	+ 4.60	4.17	−0.86	7.00	+0.13	6.00	−2.06	11.05	+ 0.16	6.52	− 2.28	7.01	+ 1.64	....	
1909..............	4.35	+0.54	1.63	−1.38	2.87	−0.55	3.64	−1.62	6.84	− 2.36	6.42	− 0.63	5.52	+0.49	8.14	+1.27	15.96	+7.90	11.85	+ 0.96	21.22	+12.42	1.73	− 3.64	....	
1910..............	5.29	+1.48	2.20	−0.81	4.45	+1.03	3.56	−1.70	5.23	− 3.97	5.74	− 1.31	5.57	+0.54	7.52	+0.65	8.71	+0.65	14.74	+ 3.85	7.61	− 1.19	12.14	+ 6.77	....	
1911..............	4.35	+0.54	1.44	−2.37	2.02	−1.40	4.00	−1.26	10.31	+ 1.11	3.81	− 3.24	2.22	−1.81	4.37	−2.50	5.71	−2.35	8.28	− 2.61	4.92	− 3.88	8.46	+ 3.09	June-	29.88
1912..............	4.40	+0.59	2.34	−0.67	4.88	+1.46	2.21	−3.05	4.60	− 1.60	2.43	− 4.62	4.30	−0.73	6.38	−0.49	6.23	−1.83	8.25	− 2.64	26.74	+17.94	3.50	− 1.87	Oct.	
1913..............	3.64	−0.17	1.14	−1.87	3.79	+0.37	7.94	+2.68	8.06	− 1.14	3.80	− 1.25	4.48	−0.55	5.50	−1.37	6.90	−1.16	7.02	− 3.87	8.65	− 0.15	3.42	− 1.95	May-	31.30
1914..............	2.65	−1.16	2.06	−0.95	4.10	+0.68	4.74	−0.52	6.62	− 2.58	5.24	− 1.81	2.94	−2.09	4.22	−2.65	3.76	−4.30	6.33	− 4.56	9.74	+ 0.94	4.96	− 0.41	Oct.	
1915..............	6.32	+2.51	2.90	−0.11	3.23	−0.19	8.77	+3.51	6.44	− 2.76	11.90	+ 4.85	5.82	+0.79	14.10	+7.23	16.68	+8.62	10.73	− 0.16	11.01	+ 2.21	6.05	+ 0.68	....	
1916..............	3.57	−0.30	5.24	+2.23	2.73	−0.69	8.18	+3.92	15.55	+ 6.35	6.33	− 0.72	7.56	+2.53	13.84	+6.97	7.62	−0.44	16.26	+ 5.37	17.80	+ 9.00	1.60	− 3.77	....	
1917..............	3.08	−0.73	3.27	+0.26	2.50	−0.92	7.07	+1.81	7.35	− 1.85	8.32	+ 1.27	5.21	+0.18	7.52	+0.65	15.43	+7.37	6.84	− 4.05	9.40	+ 0.60	4.94	− 0.43	....	
1918..............	0.88	−2.93	3.38	+0.37	5.82	+2.40	6.38	+1.08	12.56	+ 3.36	5.06	− 1.99	3.60	−1.43	7.26	+0.39	5.41	−2.65	8.94	− 1.95	5.03	− 3.77	4.60	− 0.77	....	
1919..............	6.29	+2.48	2.50	−0.51	1.92	−1.50	7.44	+2.18	14.57	+ 5.31	3.46	− 3.59	4.33	−0.70	3.54	−3.33	6.20	−1.84	7.69	− 3.20	5.11	− 3.69	6.46	+ 1.09	June-	22.84
1920..............	2.82	−0.99	2.40	−0.61	3.41	−0.01	0.29	−4.97	8.20	− 1.00	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	.....	....	May.	

TABLE 5.—*Droughts and sun spots.*

Droughts.	Inches.	Duration.	Sun.	D-S.
1873.0	39	24	1870.6	+2.4
1875.9	19	12	....	....
1880.9	17	13	*1878.9*	+2.0
1885.9	39	32	1884.0	+1.9
1891.2	20	12	*1890.[illegible]*	+1.0
1897.2	18	10	1894.0	+3.2
1899.7	21	13	....	....
1903.3	13	10	*1901.9*	+1.4
1908.0	31	15	1906.4	+1.6
1912.8	30	17	....	....
1914.8	31	18	*1913.6*	+1.2
1920	22+	12+	1918.6	....

TABLE 6.

Interval.				Deficiency.		Duration.		Intensity.	
Max.	Dev.	Min.	Dev.	Max.	Min.	Max.	Min.	Max.	Min.
2.4	+0.1	2.0	+0.6	39	17	24	13	1.6	1.3
1.9	−0.4	1.0	−0.4	39	20	32	12	1.2	1.7
3.2	+0.9	1.4	0.0	18	13	10	10	1.8	1.3
1.6	−0.7	1.2	−0.2	31	31	15	18	2.1	1.7
2.3	±0.5	1.4	±0.3	32	20	20	13	1.7	1.5

DISCUSSION.

I notice that the drought around 1873 coincides with world-wide low temperatures, probably of volcanic origin; that the drought around 1883 agrees with the cold period at the time of the Krakatoa eruption; and that the drought around 1912 was at the time of the Katmai eruption.—*W. J. Humphreys.*

The explanation for these droughts which occurs to me is as follows: (1) That on account of probable subnormal ocean-surface temperatures to windward the moisture content of the air passing over Jamaica is reduced, and therefore convectional currents of normal strength must produce less rainfall than usual; (2) that water colder than usual in this region would not only reduce the moisture content of the air, but also, by keeping the air cooler, would reduce the usual intensity of development of the low pressures that mark this region in the warmer half year, and, therefore, prevent the attainment of the usual strength of the convectional currents. The combination of reduced moisture and reduced convection would favor the occurrence of droughts. The fact that the droughts are general would indicate the operation of some such generally effective cause.

It has been found that a reduced temperature of the equatorial current (as indicated in the temperature of the Gulf Stream) follows after a month or months with unusually strong trade winds. Such winds tend to concentrate the warm surface layers to windward, which are replaced by cooler water from below and from higher latitudes. The reduction in water-surface temperatures about the West Indies seems to reach its maximum five months to a year after the occurrence of unusually strong trades in the eastern Atlantic.[1]

How can this be connected with sun spots? Prof. Pickering shows that the worst droughts come just after sun-spot maxima. It is generally conceded that the general circulation of the atmosphere is intensified by the greater amount of heat which probably enters the atmosphere at times of sun-spot maxima. Therefore, the trades, sharing in this general intensification, would produce first a plus and then a minus departure in water-surface temperature, as explained above, and in the course of 6 to 10 months the drought effects would become noticeable first in northeastern Brazil and then in the West Indies. Since the maximum intensity of the general circulation would necessarily lag after the maximum of sun spots, the total delay in the occurrence of the worst drought conditions may be easily accounted for in this way.—*Charles F. Brooks.*

In a letter of September 7, 1920, Prof. Pickering asks whether the cold-water speculations presented above would account for the droughts in California and Australia.

Discussing why the dates of the end of the droughts were chosen rather than the beginning, Prof. Pickering adds the following to what he presented in his paper:

The end of a drought is the time of the maximum deficiency of water; it is a perfectly definite date and is what particularly interests agriculturists. Different persons might select different dates for the beginning. I do not believe that the sun spots themselves, or their absence, cause the droughts. The spots are merely a surface indication of an overturn of material and temperature occurring beneath the solar surface in connection with magnetic storms. The accumulation of these conditions reaches its greatest rate of change at about the time of the end of the drought. This is indicated by the recorded magnetic variations. What the precise logical connection may be between the droughts and the magnetic disturbances I do not pretend to know, but the sun spots come first, and enable the prediction to be made. I have only to derive statistics from observed rainfall data to show the coincidence.

[1] See MO. WEATHER REVIEW November 1918, 46:510–512.